CLAIMS

1. A photo-detector with a reduced G-R noise, comprising a sequence of a p-type contact layer, a middle barrier layer and an n-type photon absorbing layer, said middle barrier layer having an energy bandgap significantly greater than that of the photon absorbing layer, and there being no layer with a narrower energy bandgap than that in the photon-absorbing layer.
2. A photo-detector according to claim 1, wherein the following band alignments exist when all the bands are flat: the valence band edge of the barrier layer lies below the conduction band edge of the photon absorbing layer, the valence band edge of the contact layer lies below its own conduction band edge or the conduction band edge of the barrier layer by more than the bandgap energy of the photon absorbing layer;
3. A photo-detector according to claim 2, wherein the middle barrier layer is a p-type material.
4. A photo-detector according to claim 2, wherein the middle barrier layer is an n-type material.
5. A photo-detector according to claim 2, wherein when biased with an externally applied voltage, the bands in the photon absorbing layer next to the barrier layer are flat or accumulated, and when flat, the valence band edge of the photon absorbing layer lies below that of the barrier layer which in turn lies below that of the contact layer.
6. A photo-detector according to claim 2, wherein when biased with an externally applied voltage, the bands in the photon absorbing layer next to the barrier layer are flat or accumulated, and the valence band edge of the flat part of the photon absorbing layer lies below the valence band edge of the contact layer and an energy of not more than $10kT_{op}$ above the valence band edge in any part of the barrier layer, where k is the Boltzman constant and T_{op} is the operating temperature.
7. A photo-detector according to claim 2 wherein the photon absorbing layer has a typical thickness of 1-10μ and doping of n $<10^{16}$ cm^{-3}.

8. A photo-detector according to claim 2, wherein the photon absorbing layer is an $InAs_{1-x}Sb_x$ alloy.
9. A photo-detector according to claim 2 wherein the photon absorbing layer is a type II superlattice material which comprises alternating sub-layers of $InAs_{1-w}Sb_w$ and $Ga_{1-x-y}In_xAl_ySb_{1-z}As_z$ with $0\leq w \leq 1$, $0\leq x \leq 1$, $0\leq y \leq 1$, $0\leq z \leq 1$ and $x + y < 1$ and wherein the sub-layers each have a thickness in the range of 0.6-10 nm.
10. A photo-detector according to claim 2, wherein the photon absorbing layer is InSb or an $In_{1-x}Al_xSb$ alloy.
11. A photo-detector according to claim 2 wherein the contact layer is p-type GaSb.
12. A photo-detector according to claim 2, wherein the contact layer is a p-type, type II superlattice comprising alternating sub-layers of $InAs_{1-w}Sb_w$ and $Ga_{1-x-y}In_xAl_ySb_{1-z}As_z$ with $0\leq w \leq 1$, $0\leq x \leq 1$, $0\leq y \leq 1$, $0\leq z \leq 1$ and $x + y < 1$ and wherein the sub-layers have a thickness in the range of 0.6-10 nm.
13. A photo-detector according to claim 2 wherein the contact layer is InSb or an $In_{1-x}Al_xSb$ alloy.
14. A photo-detector according to claim 2 wherein the middle barrier layer is a $Ga_{1-x}Al_xSb_{1-y}As_y$ alloy with $0\leq x \leq 1$ and $0\leq y \leq 1$.
15. A photo-detector according to claim 2 wherein the middle barrier layer is an $In_{1-x}Al_xSb$ alloy.
16. A photo-detector according to claim 2 wherein the middle barrier layer has a thickness of between 0.05 and 1μm.
17. A photo-detector according to claim 2 wherein the barrier layer is low-doped p-type, typically $p < 10^{15}$ cm^{-3}, and a p-n junction is formed between said barrier layer (12) and the n-type photon absorbing layer.
18. A photo-detector according to claim 2 wherein the barrier layer is doped p-type, $p < 5 \times 10^{16}$ cm^{-3} and a p-n junction is formed between said barrier layer and an n-type δ–doping layer formed at the edge of the photon absorbing layer.

19. A photo-detector according to claim 2 wherein the barrier layer is doped n-type, $n < 5 \times 10^{16}$ cm^{-3}, and a p-n junction is formed between said barrier layer and a p-type, $p < 5 \times 10^{18}$ cm^{-3}, contact layer.

20. A photo-detector according to claim 2 wherein an n-type δ–doping layer, typically with $5 \times 10^{10} < n < 10^{12}$ donors cm^{-2}, is included at the edge of the photon absorbing layer.

21. A photo-detector according to claim 2 in which the n-type photon absorbing layer is terminated by a highly n-doped, $n < 3 \times 10^{18}$ cm^{-3}, terminating layer of thickness 0.5 - 4μ, so that the valence band edge of said highly n-doped terminating layer lies below that of the n-type photon absorbing layer.

22. A photo-detector according to claim 2, grown on substrate selected from GaSb, InSb, InAs, GaAs, Ge, Si, InP or other substrate related material.

23. A photo-detector according to claim 2, grown on a compliant substrate

24. A photo-detector according to claim 2, grown by Liquid Phase Epitaxy (LPE).

25. A photo-detector according to claim 2, grown by vapour phase epitaxy, such as Molecular Beam Epitaxy (MBE) or Metal-Organic Vapour Phase Epitaxy (MOVPE) or one of their derivatives.

26. A photo-detector with a reduced G-R noise, comprising a sequence of a n-type contact layer, a middle barrier layer and an p-type photon absorbing layer, said middle barrier layer having an energy bandgap greater than that of the photon absorbing layer, and there being no layer with a narrower energy bandgap than that in the photon-absorbing layer.

27. A photo-detector according to claim 26, wherein the following band alignments exist when all the bands are flat: the conduction band edge of the barrier layer lies above the valence band edge of the photon absorbing layer, the conduction band edge of the contact layer lies above its own valence band edge or the valence band edge of the barrier layer by more than the bandgap energy of the photon absorbing layer.

28. A photo-detector according to claim 27, wherein the middle barrier layer is a p-type material.

29. A photo-detector according to claim 27, wherein the middle barrier layer is an n-type material.

30. A photo-detector according to claim 27, wherein when biased with an externally applied voltage, the bands in the photon absorbing layer next to the barrier layer are flat or accumulated, and when flat, the conduction band edge of the photon absorbing layer lies above that of the barrier layer which in turn lies above that of the contact layer.

31. A photo-detector according to claim 27, wherein when biased with an externally applied voltage, the bands in the photon absorbing layer next to the barrier layer are flat or accumulated, and the conduction band edge of the flat part of the photon absorbing layer lies above the conduction band edge of the contact layer, and an energy of not more than $10kT_{op}$ below the conduction band edge in any part of the barrier layer, where k is the Boltzman constant and T_{op} is the operating temperature.

32. A photo-detector according to claim 27 wherein the photon absorbing layer has a typical thickness of 1-10μ and doping of $p < 10^{16}$ cm^{-3}

33. A photo-detector according to claim 27 wherein the barrier layer is a low-doped n-type material and a p-n junction is formed between said barrier layer and the p-type photon absorbing layer.

34. A photo-detector according to claim 27 wherein the barrier layer is doped n-type, $n < 5 \times 10^{16}$ cm^{-3} and a p-n junction is formed between said barrier layer and a p-type δ–doping layer formed at the edge of the photon absorbing layer.

35. A photo-detector according to claim 27 wherein the barrier layer is doped p-type, $p < 5 \times 10^{16}$ cm^{-3}, and a p-n junction is formed between said barrier layer and a n-type, $n < 5\times10^{18}$ cm^{-3}, contact layer.

36. A photo-detector according to claim 27 wherein a p-type δ–doping layer is included at the edge of the photon absorbing layer.

37. A photo-detector according to claim 27 in which the p-type photon absorbing layer is terminated by a highly p-doped, $p < 3 \times 10^{18}$ cm^{-3}, terminating layer of thickness 0.5 - 4μ, so that the conduction band edge of the highly p-doped terminating layer lies above that of the p-type photon absorbing layer.

38. A photo-detector sensitive to more than one wavelength band, comprising stacked detector units as in claim 1, claim 26, or a combination thereof, in which each detector unit has a different cut-off wavelength.

39. An array of identical detectors in which each detector is as in claim 1 or as in claim 26, connected to a silicon readout circuit by indium bumps.

40. An array of identical detectors in which each detector is sensitive to more than one wavelength band as in claim 38, and in which each detector is connected to a silicon readout circuit using one indium bump or using one indium bump per wavelength band.